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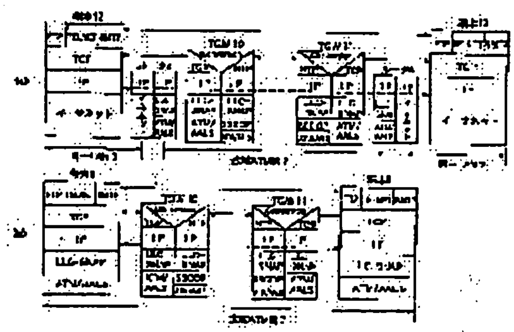
(54) TCP COMMUNICATION ACCELERATING DEVICE

(57)Abstract:
PROBLEM TO BE SOLVED: To efficiently use a buffer in the case of dealing with plural TCP connections in a TCP gateway to be used for a network system for executing inter-LAN communication by TCP/IP through a wide area network.
SOLUTION: In each of both TCP gateways arranged on transmitting and receiving sides, processing for terminating TCP flow control and resending control for a TCP packet sent from a transmitting side terminal as a substitution for a receiving side terminal, transferring the packet by using an independent flow control procedure between oppositely arranged identical devices and a selective resending procedure on a data link layer using SSCOP and transferring the packet to the receiving side terminal in accordance with a TCP processing procedure as a substitution for the transmitting side terminal is simultaneously applied to plural TCP connections.



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[Title of the Invention] TCP communication accelerating device

[Abstract]

[Object]

When a plurality of TCP connections are handled in a TCP gate wafer used for a network system for performing communications between LANs based on a TCP/IP through a wide area network, effective use of a buffer can be realized.

[Solving means]

In TCP gateways arranged in a transmitting side and a receiving side, the processes of: terminating a TCP flow control and a retransmission control against a TCP packet from the transmitting side terminal in place of the receiving side terminal; transmitting the packet between the apparatuses oppositely arranged by using a specific flow control procedure and a selective retransmission procedure at a data link layer using a SSCOP; and further transmitting the packet in accordance with the TCP processing procedure against the receiving side terminal in place of the transmitting side terminal are provided simultaneously for a plurality of TCP connections.

[What is claimed is]

[Claim 1]

A TCP communication accelerating device applied to both ends of a wide area network which realizes a data communication based on a TCP/IP by making connection among a plurality of LANs,

the TCP communication accelerating device

characterized in that it is furnished with a packet relay function at a data link in an OSI reference model and

comprises:

a packet processing means for providing a process up to the TCP in a transport layer in the OSI reference model against the received packet;

a termination means for terminating a TCP flow control and a retransmission control against a TCP packet inputted from the transmitting side terminal in place of the receiving

side terminals;

a first packet transmission means for transmitting a packet by using a selective retransmission process at a data link layer which uses a specific flow control process and the SSCOP between the apparatuses oppositely arranged through

the wide area network; and

a second packet transmission means for transmitting the packet in accordance with the TCP flow control and the retransmission control against the receiving side terminal in place of the transmission side terminal,

and provides simultaneously the processing of the above described termination means, the first and the second packet transmission means against a plurality of TCP connections.

[Claim 2]

The TCP communication accelerating device according to claim 1 characterized in that the flow control is provided for each TCP connection based on a wide window size corresponding to a delay and the flow control intended for all the TCP connections is performed between the apparatuses oppositely arranged.

[Detailed Description of the invention]

The present invention relates to a TCP communication accelerating device used for communications between wide area networks (Local Area Network).

[Prior Art]

Generally, when communications between LANs are made by TCP/IP via wide area networks, an interconnection apparatus is used, which performs a process up to the third layer (network layer) level in an OSI reference model referred to as a router for the connection between the LAN and the wide area network. This interconnection apparatus realizes a protocol process up to the network layer from physical layer in the OSI reference model, while the flow control and an error control are performed by the TCP between the terminals end to end.

In the communications where the flow control and the error control are performed by the TCP between the terminals end to end as described above, there are problems in that the throughput corresponding to a band is not obtained in case of a delay, an error, a congestion and the like. In contrast, by introducing a new parameter referred to as a window scale by expanding the TCP so as to realize a larger window size, there is proposed a means by which the throughput in case of a large delay can be improved. However, in order to effectively utilize

a large window size by this means, not only the expanded TCP is required to be introduced to both of terminals performing the communications, but also both terminals are required to adjust the size of the TCP window for each communication partner and application. On the other hand, as a means for avoiding the lowering of the throughput due to the delay, there is previously disclosed a method in Japanese Patent Laid-Open No. 7-250100 and the like where the interconnection apparatus is allowed to perform a process up to the TCP and a specific protocol is introduced between interconnection apparatuses, thereby realizing the flow control of a link by a link.

[Problem to be solved by the Invention]

The interconnection apparatus for performing the process up to the TCP such as described as above adapts a protocol having a large window size to perform the flow control corresponding to a delay. At this time, because a large window size is allotted to each TCP connection and the flow control is provided individually, an effective utilization of the buffer can not be realized and there is a possibility of causing a buffer overflow when a plurality of TCP connections are handled.

An object of the present invention is to provide a TCP communication accelerating device capable of performing an effective utilization of the buffer when a plurality of TCP connections are handled.

[Means for solving Problem]

In order to achieve the above described object, the present invention according to claim 1 is characterized in that it is a TCP communication accelerating device applied to both terminals of the wide area network realizing data communications based on a TCP/IP by making connection among a plurality of LANs and furnished with a packet relay function at a data link layer in the OSI reference model and

comprises: a packet process means for providing a process up to the TCP of a transport layer in the OSI reference model against the received packet; a termination means for terminating a TCP flow control and a retransmission control against a TCP packet inputted from the transmitting side terminal in place of the receiving side terminal; a first packet transmission means for transmitting a packet by using a specific flow control process between the apparatuses oppositely arranged through a wide area network and a selective transmission process at a data link layer using a SSCOP; and a second packet transmission means for transmitting the packet in accordance with the TCP flow control and the retransmission control against the receiving side terminal in place of the transmission side terminal and provides simultaneously the processing of the above described termination means and the first and second packet transmission means against a plurality of TCP connections.

The present invention according to claim 2 is characterized in that in claim 1 it provides the flow control based on a large window size corresponding to a delay for each TCP connection between the apparatuses oppositely arranged and performs the flow control intended for all the TCP connections.

The above described TCP communication accelerating device gives the packet a sequence number (global sequence number) which is common to all the TCP connections apart from the sequence number given to each TCP connection for the flow control for all the TCP connections, and based on the maximum value of the number of data packets which can be kept inside the apparatus set previously, the maximum value of the global sequence number receivable is notified to the opposite

side. At the transmitting side, the packet can be transmitted till it reaches the global sequence number notified.

Further, at each TCP connection, when a TCP data packet is received from the transmitting side, if there is a space in the window given to each TCP connection and yet there is a global credit available, the packet is transmitted to the opposite side. If there is no global credit available, a transmission awaiting cue is controlled in TCP connection units.

Further, in the flow control for all the TCP connections, in order that both of the apparatuses do not run into a deadlock while in a state of awaiting the credit, a renewal of the global sequence number is not performed against a global credit notice which is not kept inside the apparatus and does not include user data, ACK, SYN, FIN, RST and the like, thereby the flow function is not allowed to function.

Furthermore, when the transmission to the opposite side becomes newly possible by the flow control against all the TCP connections, a throughput fairness can be secured by transmitting the packet in order of size of the space given to the window of each TCP connection.

[Embodiment of the Present Invention]

Hereinafter, the embodiment in the case where a TCP communication accelerating device according to the present invention is applied to TCP gateways will be described.

FIG. 3 is a schematic block diagram of a network system based on a wide area ATM (Asynchronous Transfer Mode) network. To LAN 1, LAN 2 which are located at physically isolated positions, terminals 12, 13 are connected respectively and connected to the wide area ATM network 7 through routers 3,4 and ATM exchanges 5, 6. Similarly, ATM terminals 8, 9 which are located at physically isolated positions are

connected to the wide area ATM network 7 through the ATM exchanges 5, 6. TCP gateways (hereinafter, referred to as TGW) 10, 11 are connected to the above described ATM exchanges 5, 6 and relay the packet in the following manner.

FIG. 1 is an explanatory drawing showing a protocol structure of the network system as shown in FIG. 3. FIG. 2 is an explanatory drawing showing more in detail the protocol structure of a TGW 10 (11) as shown in FIG. 1 and the flow of packets.

Note that FIG. 1 shows an example intended for TCP/IP as protocols of LANs 1, 2. Among them, FIG. 1 (a) shows a protocol stack between terminals 12, 13 and FIG. 1 (b) a protocol stack between ATM terminals 8, 9 respectively. Further, in FIG. 1 and FIG. 2, an IP portion of the TGWs 10, 11 performs only the checking of addition, removal of an IP header and a parameter and shall not be provided with an IP routing function. Further, a LLC-SNAP portion is used as occasion demands.

The TGW 10 (11) is furnished with a packet relay function at a data link layer and comprises: a packet process means for providing a process up to the TCP of a transport layer against the received packet; a termination means for terminating the TCP flow control and the retransmission control against the TCP packet inputted from the ATM terminal 8 of the transmitting side in place of the ATM terminal 9 of the receiving side; a first packet transmission means for transmitting a packet between the apparatus 11 oppositely arranged through the wide area network 7 by using a specific flow control process and a selective retransmission process at the data link layer using a SSCOP; and a second packet transmitting means for transmitting a packet in accordance with the TCP processing procedure against the ATM terminal 9 in place of the ATM terminal 8 and provides simultaneously

the processing of the above described termination means and the first and the second packet transmitting means. In particular, between the apparatuses oppositely arranged, the flow control based on the wide window size corresponding to the delay is provided for the each TCP connection and the flow control intended for all the TCP connections is also performed.

Next, the procedure of the TGWs 10, 11 in case of transferring packets between terminals will be described. Note that, in this example, capsulization of the packet by using a LLC-SNAP (Logical Link Control-Subnetwork Access Protocol) is performed.

1. Because the ATM terminals 8, 9 or the routers 3,4 (hereinafter, referred to as terminals) transmit the packet through the wide area ATM network, the packet is outputted by using a previously set VCC (Virtual Channel connection).

2. Both of ATM exchanges 5, 6 terminate the VCC primarily set between the terminals at the TGWs of each side against the VCC required to be processed at the TGWs 10, 11. For each terminated VCC, the VCC for a relay and a SSCOP connection to be described later are set up separately between the TGWs. The TGWs 10,11 allow the terminal side VCC and the opposite TGW side VCC to correspond one to one and exchange the packet at the data link level.

3. The TGW 10(11) checks the packet capsulized and transmitted by the LLC-SNAP from the terminal 8 (9) and converts the TCP packet intended for a TWG process from a TCP to a HTP and, by making an AA-DATA. request to the SSCOP, performs a data transmission of a confirmatory type by a SD PUD. Against the input from the opposing TGW 9 (8), the process is performed in reverse. The packet which is not treated with the TGW process is allowed to make a request for an AA-UNITDATA. request

to the SSCOP and perform the data transmission of a non-confirmatory type and pass through the TGW as it is.

Note that the above described SSCOP is a confirmatory type protocol provided with a powerful selective retransmission function. By using this SSCOP, no longer is there the necessity of considering a loss of HTP packets between the TGWs.

Next, the procedure of establishing a HTP connection will be described.

The TGWs 10, 11 allow the procedure of the establishment of the TCP connection to be made end to end and, by utilizing this procedure, the HTP connection is established. FIG. 4 shows a communication sequence at the time of establishing the HTP connection. The procedure of establishing the HTP connection is shown as follows.

1. In order to establish the connection, the TCP converts three packets of SYN, SYN+ACK and ACK to establish the connection. At the time of receiving a TCP-SYN from a terminal 1, a TGW 1 prepares a connection table for controlling the TCP.HTP connection and rewrites the received TCP-SYN into a HTP-SYN, which is transmitted to a TGW 2. Henceforth, when the TCP-SYN which is retransmitted from the terminal 1 is received, it is cancelled.

2. The TGW 11 which receives the HTP-SYN similarly prepares the connection table and rewrites the HTP-SYN into the TCP-SYN and transmits it to the terminal 9. When the TCP-SYN is lost, it is retransmitted by a timer.

3. The TGW 11 which receives a TCP-SYN + ACK rewrites this into a HTP-SYN + ACK and transmits it to the TGW 10. Henceforth, when the TCP-SYN + ACK is retransmitted from the terminal 9 by the time a HTP-ACK is received from the TGW 10, it is cancelled.

4. The TGW 10 which receives a HTP-SYN-ACK rewrites this into the TCP-SYN + ACK and transmits it to the terminal 8. When the TCP-SYN + ACK is lost, it is retransmitted by the timer.

5. The TGW 10 which receives a TCP-ACK rewrites this into a HTP-ACK and transmits it to the TGW 11 to establish the HTP connection.

6. The TGW 11 which receives HTP-ACK rewrites this into the TCP-ACK and transmits it to the terminal 9 to completes the establishment of the HTP connection. Henceforth, when the TCP-SYN + ACK (retransmitted) is received from the terminal 9, the TCP-ACK responds to it.

Next, the releasing procedure of the HTP connection will be described.

The releasing of the HTP connection is realized, while the releasing of the TCP connection is performed end to end. FIG. 5 shows a communication sequence at the time of the releasing of the HTP connection. The procedure thereof is usually as follows.

1. In order to release the connection, the TCP exchanges a FIN and an ACK against FIN for every communication direction. When an initial TCP-FIN is received from the terminal 8, the TGW 10 rewrites this into a HTP-FIN and transmits it to the TGW 11 after all the HTP data packets are transmitted. Henceforth, the transmission of the TCP-FIN is not confirmed to the terminal 8 until a HTP-ACK against a HTP-FIN is received from the TGW 11.

2. A TGW 2 which receives the HTP-FIN rewrites this into the TCP-FIN and transmits it to the terminal 9 after all the TCP data packets are transmitted. Henceforth, the transmission of the HTP-FIN is not confirmed to the TGW 10 until a TCP-ACK against the TCP-FIN is received from the terminal 9. Also when the TCP-FIN is lost, it is transmitted by the timer.

3. The TGW 11 which receives the TCP-ACK against the TCP-FIN transmits the HTP-ACK against the HTP-FIN to the TGW 10.

4. The TGW 10 which receives the HTP-ACK against the HTP-FIN transmits the TCP-ACK against the TCP-FIN to the terminal 8.

5. The TGW 10, against the retransmission of the TCP-FIN from the terminal 8 after the above described 4, returns the corresponding TCP-ACK.

6. When the last TCP-FIN is received from the terminal 9, the transmission thereof is confirmed end to end in the same manner as the above described 1 to 4. However, the TGW 10 (TGW 11), after the transmission of the last HTP(TCP)-ACK, takes the HTP connection as released and releases the connection table. Note that when the last TCP-ACK transmitted to the terminal 9 is lost also, the TCP-FIN and its TCP-ACK are exchangeable end to end without intervention of the HTP.

A flow sequence in the above described HTP is as follows.

1. The HTP performs a flow control by the transmission window given to each HTP connection and the global credit given to all the HTP connections among the link (=VCC), which are renewed by using the HTP-ACK and a THP-GLCDT from the opposing TGWs respectively.

2. Every time the TCP data packet (TCP-DT) held by receiving the TCP-ACK is released and a HTP-DT of the maximum HTP window size (HTP winsize)/N1[byte]is newly receivable, the window for each HTP connection notifies the renewal to the opposing TGWs. The HTP winsize and the N1 are set in advance. The HTP packet should not transmit the HTP-DT over the transmission window previously set.

3. On the other hand, the outline of the flow sequence using the global credit is as follows.

(a) The HTP notifies the common 16 bits sequence number (GSN) to all the connections. Only when the HTP packet having a data is transmitted, the GSN is increased by 1 and transmitted.

(b) By controlling the number of packets held by all the connections, the credit (the maximum value of the GSN of the receivable HTP-DT) is notified in packet units.

(c) When the GSN attached to the HTP packet is smaller than a CDT, the transmission is made possible. When the transmission is not made possible, the connection table is connected to a global waiting cue. The sequence of connection is in order of the larger space of the HTP transmission window. However, the HTP-ACK and the like which have no data do not perform the renewal of GSN and therefore can always transmit.

(d) When the HTP-DT is transmitted by the renewal of the credit, the transmission begins from the connection at the head of the cue awaiting the global transmission. Also at this time, the connection table transmitted for every packet transmission is reconnected in suitable location (in order of the space size of the HTP transmission window).

(e) Every time the TCP-DT held by receiving the TCP-ACK is released and the global window size (GL winsize)/N2 (the number)of the credit becomes newly notifiable, the renewal of the credit is notified to the opposing TGWs. The GL winsize and the N2 are set in advance.

(f) The credit value is taken as min(SSCOP max winsize, max global winsize)-(the number of TCP packets held by the TCP side) + (the GSN attached with the last received packets).

While the buffer amount prepared for the TGW by the above is regulated by the global credit, the window for each HTP connection

can use a value corresponding to a delay unless the packet stays within the TGW.

FIG. 6, FIG. 7 and FIG. 8 are flowcharts showing the processing procedure of the HTP-DT transmission. The TGW transmits the HTP-DT either by 1) the TCP-DT input, 2)the renewal of the HTP transmission window and 3) the renewal of the global credit. Hereinafter, its outline will be described.

1. The TCP-DT is inputted (FIG. 6).

The inputted TCP-DT is converted to the HTP-DT (S11) and a transmission awaiting cue inside the connection table is confirmed (S12). If the cue is not vacant, a decision is made that the transmission is not possible due to some flow control and, by connecting the HTP-DT to the HTP transmission awaiting cue, the process is over (S16). If the cue is vacant (S12), the availability of the global credit is confirmed (S13). If the credit is not available, by connecting the HTP-DT to the HTP transmission awaiting cue (S17), the HTP transmission window is subsequently confirmed (S18). If the window is open, by (newly) connecting the connection table to the global transmission cue, the process is over (S19). In the case other than the above, the process is over as it is. When there is the global credit available in S13, the HTP transmission window is confirmed (S14) and when the window is open, it is outputted to the SSCOP (S15). When the window is closed, by connecting the HTP-DT to the HTP transmission awaiting cue, the process is over (S16).

2. The HTP window is renewed (FIG. 7).

The HTP transmission awaiting cue is confirmed (S21). If the HTP-DT is not available, the process is over. If the HTP-DT is available in S21, the availability of the global credit is confirmed (S22). If there

is no credit available, by connecting the connection table to the global transmission cue or by matching and reconnecting it to the renewed HTP transmission window, the process is over (S25). When the credit is available in S22, the HTP window is confirmed (S23). If the window is open, it is outputted to the SSCOP (S24) and the process returns to S9. When the window is closed at S23, the process is over.

3. The global credit is renewed (FIG. 8)

The global transmission awaiting cue is confirmed (S31) and if the cue is vacant, the process is over. If there is the connection table in the cue at S31, the HTP-DT is taken out from the top table and outputted to the SSCOP (S32, S33). Next, a confirmation is made as to whether the HTP transmission awaiting cue and the HTP transmission window of the outputted connection are vacant and open (S34). If the HTP transmission awaiting cue is vacant or the HTP transmission window is closed, the connection table is eliminated from the global transmission awaiting cue (S37) and the global transmission cue is confirmed (S38). If the cue is vacant, the process is over. If the cue is not vacant, the process is continued from S36. When the HTP transmission awaiting cue is not vacant and the HTP transmission window is open in S34, the connection table is matched to the renewed HTP transmission window and reconnected to the global transmission awaiting cue (S35). Subsequently, the availability of the global credit is confirmed (S36). When there is no credit available, the process is over. When it is available, the process returns to S32.

FIG. 9 shows a communication sequence at the time of the data transmission including the sequence of the SSCOP.

1. The TGW 10 which receives the TCP-DT (data) from the terminal 8 returns the TCP-ACK packet according to the TCP protocol process.

2. The TGW 10 rewrites the received TCP-DT into the HTP-DT and transmits it to the TGW 11 according the flow control for every connection and the flow control of all the connections.

3. The HTP packets (HTP-DT, HTP-ACK, HTP-GWND and the like)are transmitted by the SSCOP of the TGW 10 by using the SD PDU.

4. The TGW 11 rewrites the received HTP-DT into the TCP-DT and transmits it to the terminal 2 according to the protocol process of the TCP.

5. The TGW 11 transmits, by receiving the TCP-ACK from the terminal 9, the HTP-ACK for renewing each window and a HTP-GWND for renewing the global credit to the TGW 1 every time the transmission of a constant TCP-DT is confirmed.

6. The loss of the SD is detected by exchanging a STAT PDU with an USTAT PDU or a POLL PDU, and the SSCOP retransmits the SD only for which the loss was notified. The HTP is not conscious of the retransmission at the SSCOP.

[Example]

Next, as an example, the result of the communication experiment conducted by using the TGW of the above descried embodiment will be described.

1. The configuration of the experiment

In order to verify the effect of TCP gateways, the communication experiment was conducted according to the system configuration as shown in FIG. 10. To be concrete, two sets of SPARC Station 20 (SS20:Super SPARC II 75 MHz, 128 Mbytes, Solaris 2. 5. 1) each having two pieces of ATM board (FORE SBA200E) as TGW-A, B and two sets of PC (Pentium II 233 MHz, 64 Mbytes, Solaris 2. 6) each having one piece of ATM board (FORE PCA200E) as terminals A, B are arranged and they were connected

through an ATM switch (FORE ASX200) and a data channel simulator (ADTECH SX/14) for interposing a delay and a transmission error inside the network. Moreover, as the line, OC-3 (155 Mbps) was used between the terminals and the TGWs, and OC-3 and DS-3 (45 Mbps)were used between the TGWs.

2. The content of the experiment.

The content of the experiment is as follows.

2-1. The comparison of the throughput depending on the availability of the TGWs in the case where the usual TCP (having no window scale) is used.

(a) Interposition of a reciprocating transmission time delay (RTT)of 200 msec into the DS-3 line.

(b) A state of TGW-non existing is realized by allowing two pieces of the OC-3 lines connected to the TGW to make loop-back just before they are inputted to the TGW.

(c) The window size of the TGW is taken as 1 Mbytes for each HTP connection and the maximum value of the global credit is taken as 2,048 pieces.

(d) The window size of the TCP is taken as 36,560 bytes (default value).

2-2. The comparison of the throughput between the TCP(TGW-non existing) having a window scale and (the TGW + the usual TCP) in the environment where there is a transmission error.

(a) Same as 2-1(a) to 2-1 (c).

(b) The window size of the TCP in case of (the TGW+ the usual TCP) is taken as 36,560 bytes. The TCP supporting the window scale is taken as 1 Mbytes.

(c) The number of TCP connections is taken as 1 to 4.

(d) When the TCP having the window scale is used, a traffic shaping is performed so that a data is transmitted at a speed matching the DS-3 at the terminal in order to prevent a congestion at the DS-3 line.

(e) A random bit error having any of BER = 0 (non-existing), IE-9, IE-8 and IE-7 is interposed.

2-3. The comparison of the throughput between the TCP (TGW non-existing)and (the TGW + the usual TCP)in the environment where there exists a congestion.

(a) Same as 2-2(a) to 2-2(b)

(b) No traffic shaping is performed at the terminal (the transmission is made at a speed of the OC-3). In this case, there is a possibility of causing a congestion at the output cue to the DS-3 line in the ATM switch.

(c) As shown in FIG. 11, communications are made according to three kinds of condition settings such as 1) simultaneous start and (simultaneous)completion of the transmission, 2) start of transmission at different timing simultaneous with completion of transmission (Different Start Time) and 3) a combination of large data transmission and small data transmission (Transmitting Large Data and Small Data).

3. Result.

3-1. The comparison with the usual TCP.

When the usual TCP was used, while the throughput was 1.47 Mbps at the TGW non-existing, it was improved to the level of 33.5 Mbps at the TGM-existing.

3-2 The comparison with the TCP having a window scale option(having a random bit error).

FIG. 12 shows an experiment result of the TCP having the window scale option and (the usual TCP + the TGW) in the case where the random

bit error is interposed. The axis of the ordinates of FIG. 12 represents the throughput (Total throughput) and the axis of the abscissas the bit error rate (BER), respectively. That is, this graph shows what kind of the speed is obtained under the artificial circumstance set in the bit error rate IE-09 to IE-07. A full line shows the result according to the present invention and a broken line the result according to the conventional example. Note that No. 2 and Nó. 4 channels of the TCPGW show the same full line because both of them have the same result.

As shown in FIG. 12, even when there was a transmission error by using the TGW, it became clear that the lowering of the throughput could be prevented. This is because it is considered that an error recovery function by the SSCOP in case of using the TGW and the flow control of a link by a link will function more effectively than the error recovery function by the TCP and the flow control end to end.

3-3 The comparison of the TCP having the window scale option under the circumstance having a congestion.

Condition Setting (1)

In (the TGW + the usual TCP), a total sum of the throughput was 35.9 Mbps and the throughput of each connection was 17.95 Mbps in all the cases. On the other hand, in case of the TCP attached with the window scale option, a total sum of the throughput was 31.4 Mbps and the throughput of each connection was 18.6 Mbps and 13.6 Mbps in the worst case. From this result, it is clear that the TGW realizes the communication which is fair and high in utilization efficiency of the line. This is because it is considered that as the TCP attached with the window scale performs the flow control end to end, a congestion occurs at a time when an output is made to the DS-3 in the ATM switch,

while the TGW controls the transmission from the terminal at the TCP side and can transmit the HTP packet at a transmission rate according to the DS-3 line, thereby causing no congestion to occur.

Condition Setting (2)

In (the TGW + the usual TCP), the throughput of the first starting connection 1 was 18 Mbps and the throughput of the next starting connection 2 was 17.9 Mbps. On the other hand, in case of the TCP attached with the window sale option, it was 19.2 Mbps and 14.3 Mbps, respectively. From these results in addition to the knowledge obtained in the condition setting (1), it is clear that the TGW can provide a fair throughput even to the connection joined afterward. This is because it is considered that, in addition to the same reason as with the condition setting (1), the TGW terminates the flow control with the transmitting side TCP under the circumstance where there is few delay, thereby quickly completing a slow start procedure which is performed to avoid a congestion in the TCP of the transmission terminal.

Condition Setting (3)

FIG. 13 shows the result of the communication experiment according to the condition setting (3). Together with the total sum of throughputs and each throughput, (the TGW + the usual TCP) obtain a higher value. In particular, the total throughputs are 34.5 Mbps in the case of the throughput transferring small amount of data, and the throughput transferring large amount of data is sharply improved. It is considered that these result depend on the same reason as condition settings (1) and (2).

[Effect of the invention]

As described above, the TCP communication accelerating device according to the present invention controls the buffer amount required from the transmission side terminal and can use effectively fairly the line band without relying on the number of connections so that an effective utilization of the buffer can be made in case of using a plurality of TCP connections.

[Brief Description of the Drawings]

FIG. 1 (a), (b) are the explanatory drawings to show the protocol configuration of a network system according to the embodiment.

FIG. 2 is an explanatory drawing to show a still further detailed protocol configuration of a TGW and the flow of packets.

FIG. 3 is a schematic block diagram of the network system based on a wide area ATM network.

FIG. 4 is an explanatory drawing to show a communication sequence at a time of the establishment of a HTP connection.

FIG. 5 is an explanatory drawing to show a communication sequence at a time of the release of the HTP connection.

FIG. 6 is a flowchart to show a processing procedure at a time of a TCP-DT inputting in the HTP-DT transmission.

FIG. 7 is a flowchart to show the processing procedure at a time of a HTP window renewal in the HTP-DT transmission.

FIG. 8 is a flowchart to show the processing procedure at a time of a global credit renewal in the HTP-DT transmission.

FIG. 9 is an explanatory drawing to show a communication sequence at a time of data transmission including the sequence of SSCOP.

FIG. 10 is a schematic diagram to show a system configuration according to the embodiment.

FIG. 11 is a explanatory drawing to show the contents of three kinds of condition settings in the embodiment.

FIG. 12 is a graph to show a result of the experiment of a TCP having a window scale option in case of interposing a random bit error and (the usual TCP + the TGW).

FIG. 13 is an explanatory drawing to show the result of the communication experiment according to the condition setting 3.

[Description of the Reference Numerals]

1, 2 ... LAN

3, 4 ... Router

5, 6 ... ATM exchange

7 ... Wide area ATM network

8, 9 ... ATM terminal

10, 11 ... TGW

FIG. 1 (a)

#1 Router (3, 4)

#2 Wide area ATM network (7)

#3 Terminal (12, 13)

#4 Insernet

FIG. 1 (b)

#1 Wide area ATM network (7)

#2 Terminal (8, 9)

FIG. 2

#1 ATM terminal side (VC ?)

#2 Opposing gateway side (VC ?)

#3 TCP packet performing relay process

#4 IP packet other than the above (?, ?, non-relay TCP, etc)

#5 LLC-SNAP capsulized packet other than the above (?,?. etc)

FIG. 3

#1 Router (3, 4)

#2 ATM exchange (5, 6)

#3 ATM terminal (8, 9)

#4 Terminal (12, 13)

#5 Wide area ATM network
(delay, error and the like available)

FIG. 4

#1 Timer retransmission

#2 Retransmission from terminal TCP and response of TP

FIG. 5

#1 Timer retransmission

#2 Retransmission from terminal TCP

FIG. 6

#1 Start

S11 Conversion to HTP-DT

S12 No HTP-DT awaiting transmission in same connection

S13 Global credit available ?

S14 HTP transmission window is open ?

S15 Output process to SSCOP

S16 Connection of HTP-DT to rear of HTP-DT awaiting cue inside connection table

S17 Connection of HTP-DT to rear of HTP-DT awaiting cue inside connection table

S18 HTP transmission window is open ?

S19 Connection of connection table

#2 END

FIG. 7

#1 Start

S21 HTP-DI available in HTP transmission awaiting cue ?

S22 Global credit available ?

S23 HTP transmission window is open ?

S24 Output process to SSCOP

S25 Connection or rearrangement of connection tables

#2 END

FIG. 8

#1 Start

S31 Global transmission awaiting cue is not vacant ?

S32 Selection of connection at head of global transmission awaiting cue

S33 Output process to SSCOP

S34 Both condition 1 * and condition 2** are true ?

S35 Rearrangement of connection tables in global transmission awaiting cue

S36 Global credit is available ?

S37 Removal of connection table from global transmission Awaiting cue

S38 Global transmission awaiting cue is vacant ?

#2 END

#3 Condition 1: Has HTP transmission awaiting que HTD-DT ?

Condition 2: Is HTP transmission awaiting window open ?

FIG. 9

#1 Retransmission of SD by SSCOP

FIG. 10

#1 Terminal A, B

FIG. 13

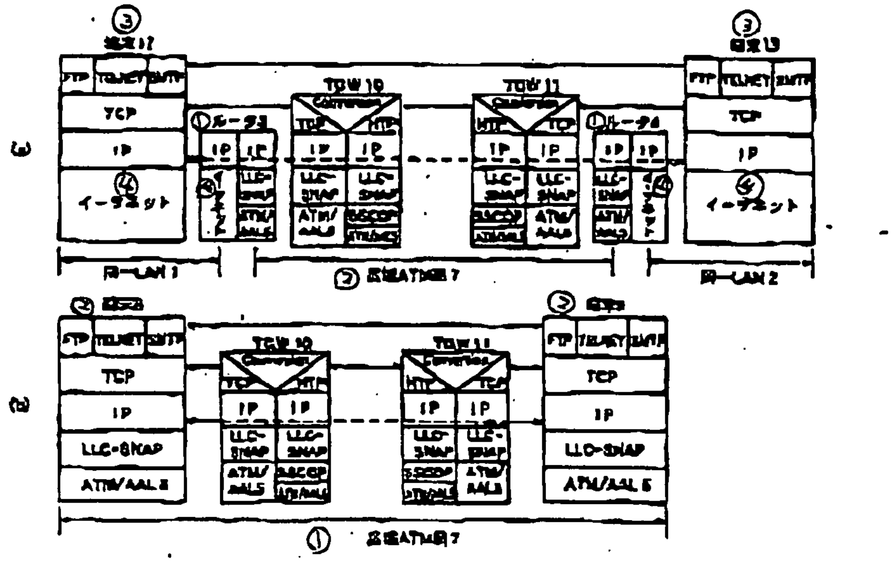
#1 Transmission of large amount data

#2 Transmission of small amount data

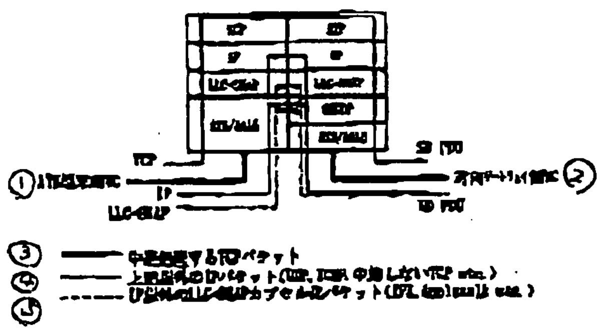
#3 Sum total

#4 TCP attached with window scale

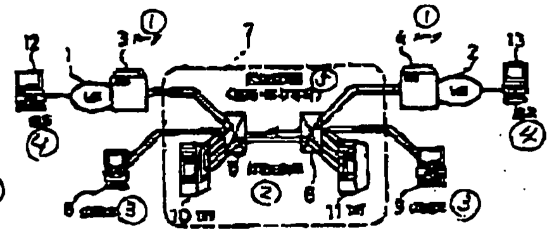
【図1】



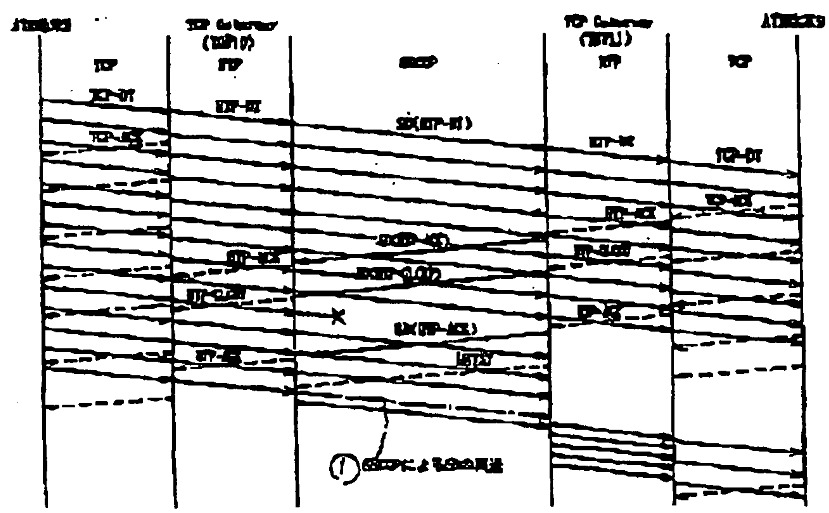
【図2】



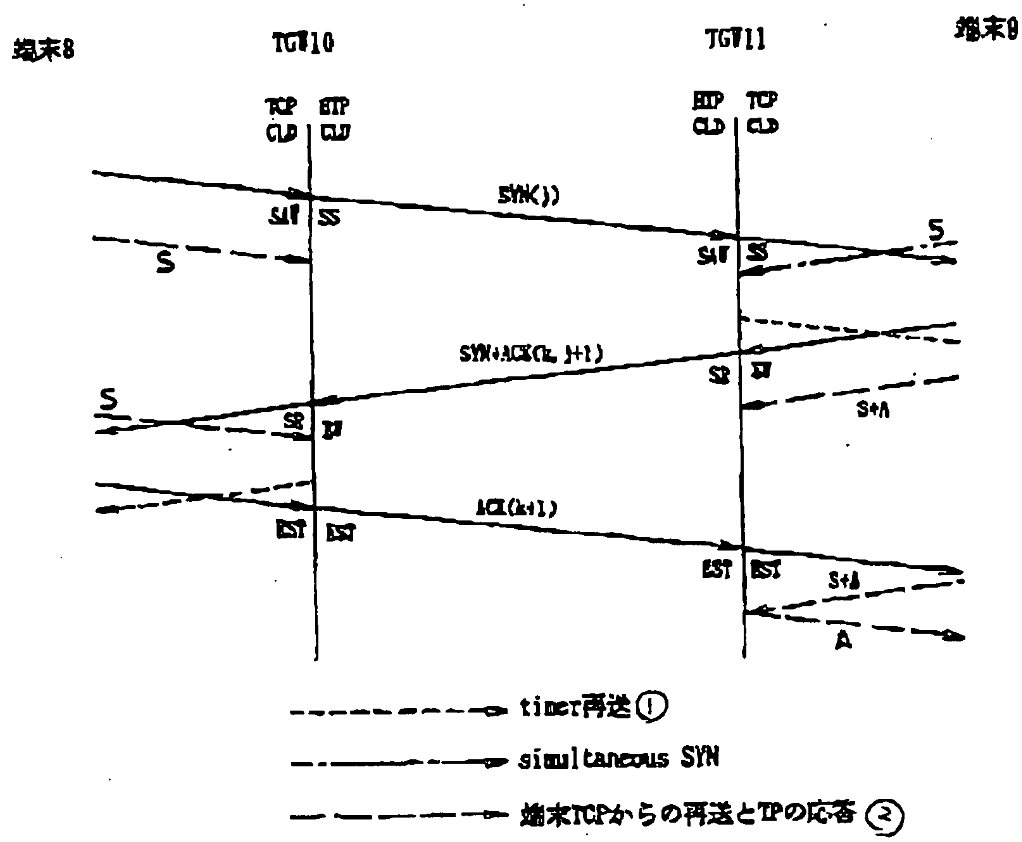
【図3】



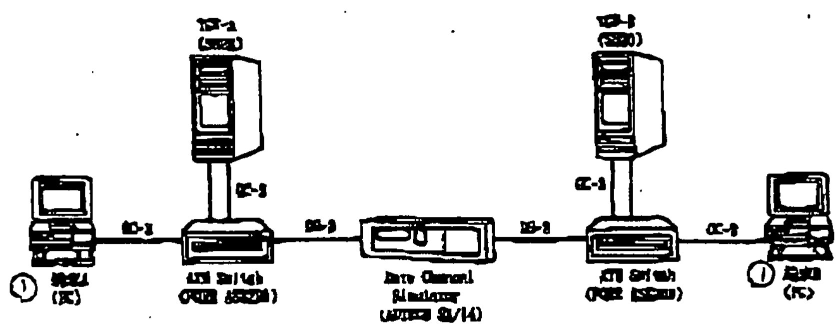
【図9】



【図4】



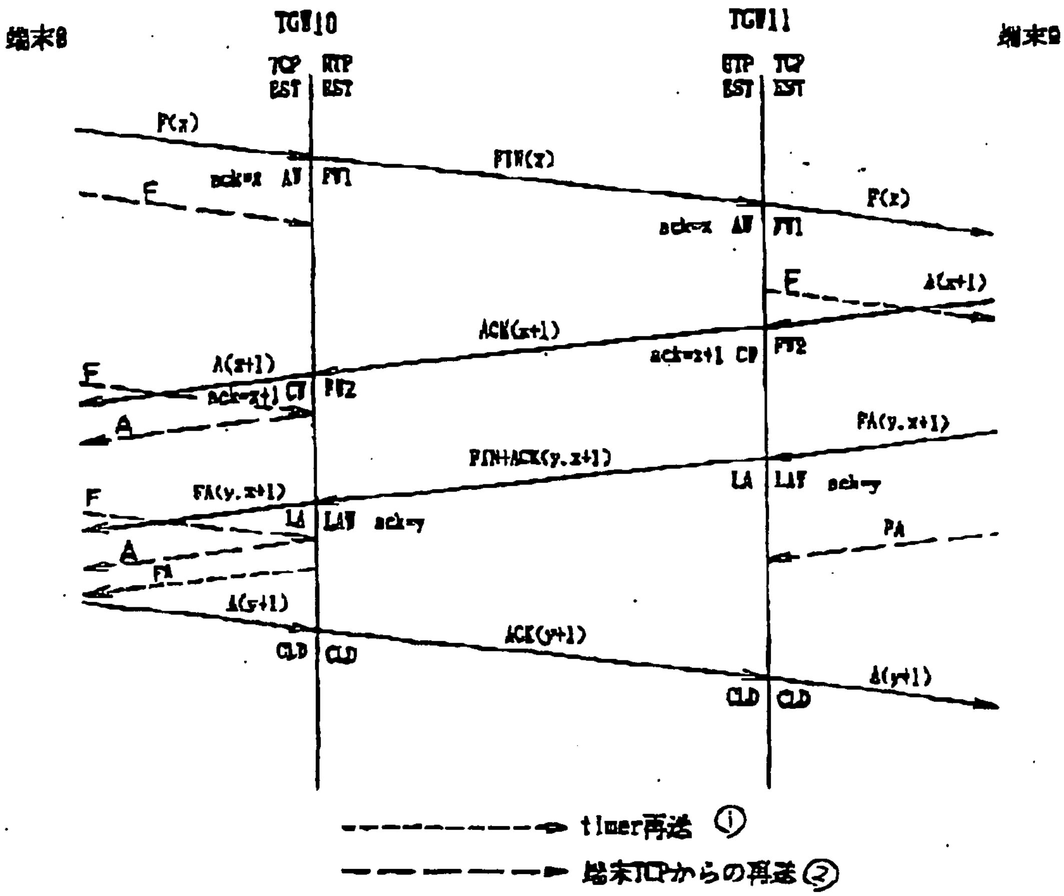
【図10】



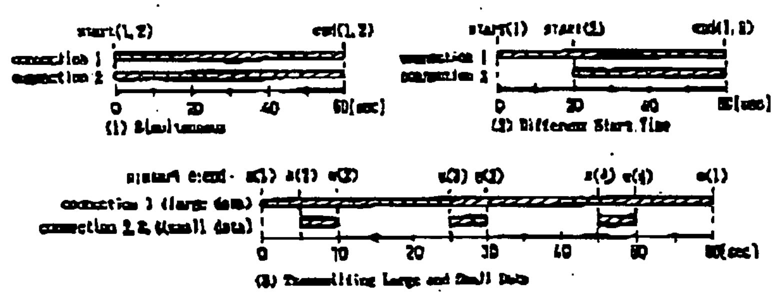
【図13】

	①大容量データ転送	②少量データ転送	③合計
既存のTCP+TGW	28.2Mbps	17.8Mbps	34.5Mbps
④ウィンドウスケール付きTCP	24.7Mbps	4.4Mbps	35.4Mbps

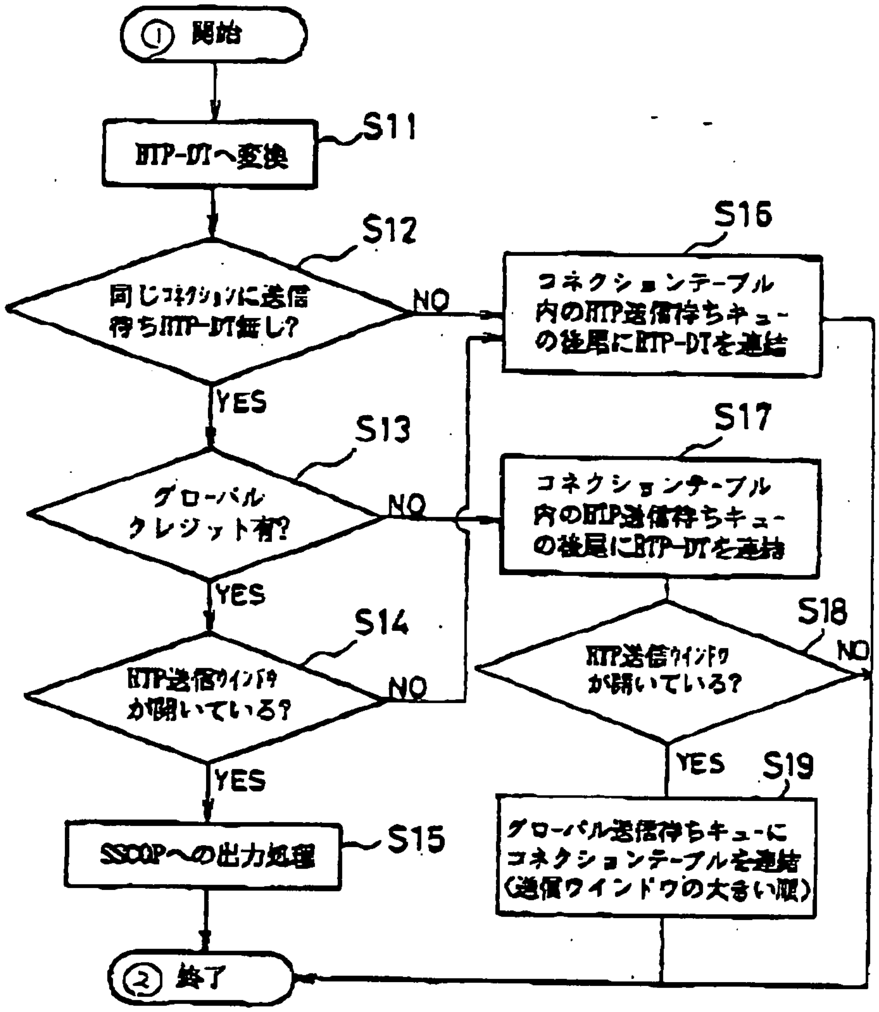
【図5】


端末8
TGW10
TGW11
端末9
TCP EST
RTP EST
RTP EST
TCP EST
F(x)
FIN(x)
F(x)
ack=x AW
FW1
A(x+1)
ACK(x+1)
A(x+1)
ack=x+1 CW
FW2
FA(y,x+1)
FIN+ACK(y,x+1)
LA
LAW ack=y
PA
A(y+1)
ACK(y+1)
CLD
timer再送 ①
端末TCPからの再送 ②

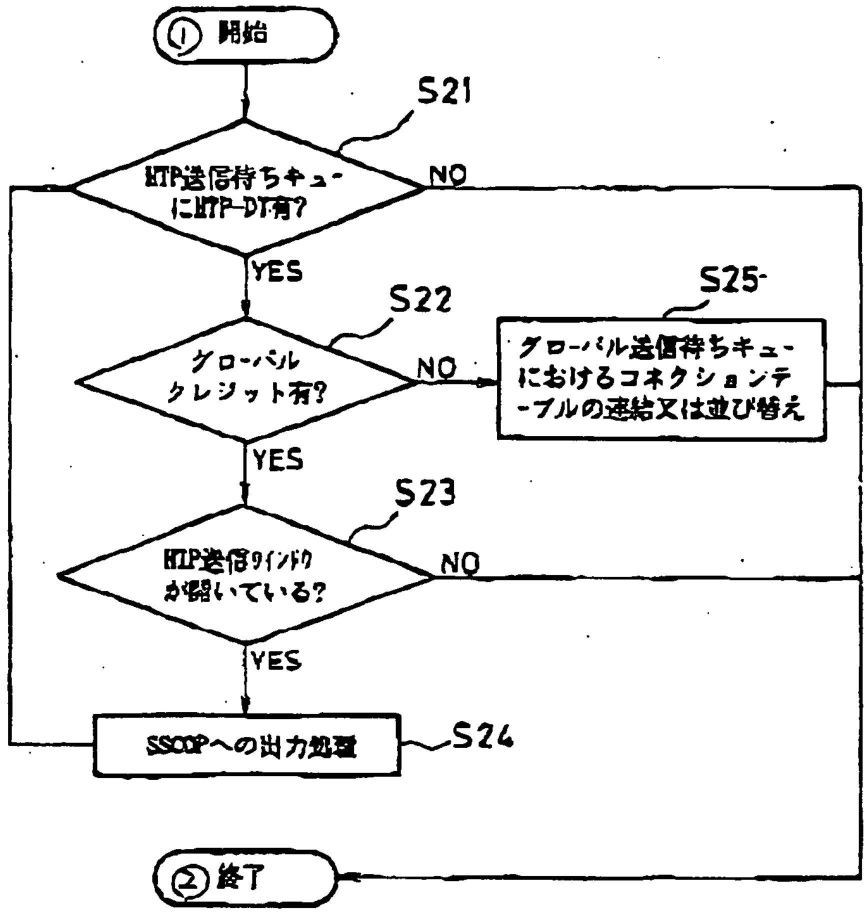
【図11】


start(1,2)
end(1,2)
connection 1
connection 2
60[sec]
(1) Simultaneous
start(1)
start(2)
end(1,2)
(2) Different Start Time
connection 1 (large data)
connection 2,3,4(small data)
80[sec]
(3) Transmitting Large and Small Data

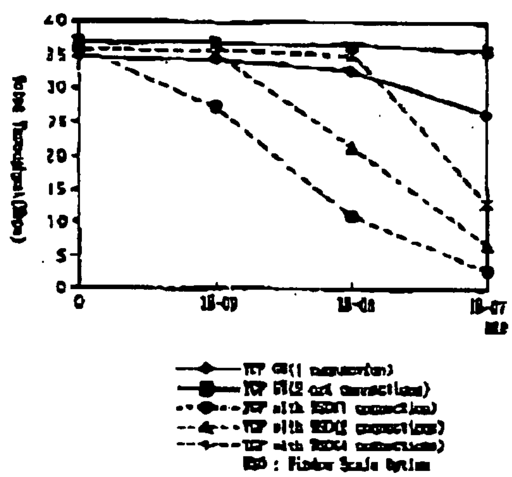
【図6】


① 開始
S11
HTP-DTへ変換
S12
同じコネクションに送信待ちHTP-DT無し?
NO
YES
S13
グローバルクレジット有?
NO
YES
S14
HTP送信ウインドウが開いている?
NO
YES
S15
SSCOPへの出力処理
S16
コネクションテーブル内のHTP送信待ちキューの後尾にHTP-DTを連結
S17
コネクションテーブル内のHTP送信待ちキューの後尾にHTP-DTを連結
S18
HTP送信ウインドウが開いている?
NO
YES
S19
グローバル送信待ちキューにコネクションテーブルを連結(送信ウインドウの大きい順)
② 終了

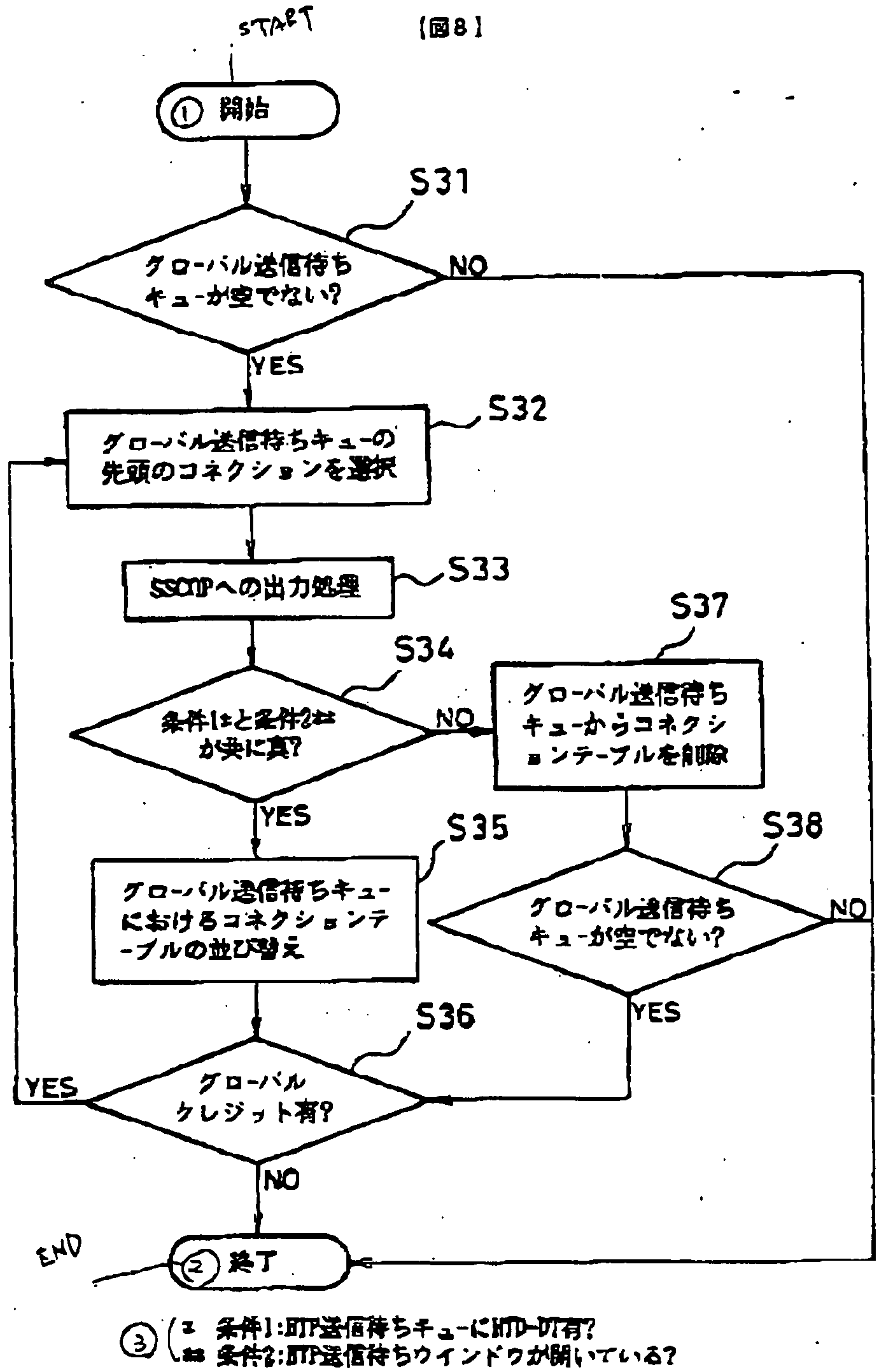
【図7】


① 開始
S21
HTP送信待ちキュー
にHTP-DT有?
NO
YES
S22
グローバル
クレジット有?
NO
S25
グローバル送信待ちキュー
におけるコネクションテ
ーブルの連結又は並び替え
YES
S23
HTP送信ウインドウ
が開いている?
NO
YES
SSCOPへの出力処理
S24
② 終了

【図12】


40
35
30
25
20
15
10
5
0
0
WSO : Window Scale Option

【図8】


START
① 開始
S31
グローバル送信待ちキューが空でない?
NO
YES
S32
グローバル送信待ちキューの先頭のコネクションを選択
S33
SSCOPへの出力処理
S34
条件1※と条件2※※が共に真?
NO
S37
グローバル送信待ちキューからコネクションテーブルを削除
YES
S35
グローバル送信待ちキューにおけるコネクションテーブルの並び替え
S38
グローバル送信待ちキューが空でない?
NO
YES
S36
グローバルクレジット有?
YES
NO
END
② 終了
③ ※ 条件1:HTP送信待ちキューにHTD-DT有?
※※ 条件2:HTP送信待ちウインドウが開いている?